Forest Practices Board

SPECIAL INVESTIGATION

High Retention Harvesting and Timber Sustainability on the British Columbia Coast

FPB/SIR/20

January 2008

Table of Contents

Executive Summary 1

Board Commentary 3

Recommendations 4

Introduction 6

- Background 6
- Objective 8
- Approach 8
- Method 10

Results 13

- Extent of High Retention Systems 13
- Background Conditions 14
- Types of Retention 15

Issues 26

- Compliance Versus Effectiveness 26
- Implementing Prescribed Retention Levels 26
- Forecasting Volume Reductions 27
- Potential For Species Shift 27
- Impacts on the Growth of Understory Regeneration 28
- Regeneration - Planting and Natural 29
- Forest Health - HW Dwarf Mistletoe (DMH) 29
- Linking Site Plans to Harvesting Outcomes 30

Conclusions 31

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Executive Summary

One of the objectives of *British Columbia's Forest and Range Practices Act (FRPA)* is to maintain and enhance an economically valuable supply of commercial timber from B.C.'s forests while ensuring sustainability. To this end, considerable work has been done on developing appropriate silvicultural systems for B.C.'s various coastal ecosystems in the last few decades. However economic realities of the forestry industry on B.C.'s north and central coast – such as remote locations and high harvesting costs – creates pressure to selectively harvest only the most valuable trees, a potential risk to long-term timber sustainability.

The objective of this investigation was to examine the sustainability of timber in cutblocks on B.C.'s coast that have been partially harvested using a high retention system (i.e., more than 50 percent of the stand is left with remaining trees dispersed across the block).

The investigation examined stand conditions in 54 cutblocks after high retention harvesting, and found that objectives set out in the planning stages for visual quality, slope stability, hydrological care, soil conservation, and wildlife habitat were largely met in these cutblocks.

However, objectives for a sustainable timber supply were not met in the majority of the cutblocks. In 60 percent of the cutblocks examined, only commercially valuable cedar, and some spruce, was harvested, and nearly all of the valuable trees in the cutblock were taken, leaving behind areas with extremely limited prospects for an economically viable future harvest, and no effective means for reforesting with valuable tree species.

In coastal, old-growth stands the most common silvicultural systems prescribed for partial cutting are the retention, irregular shelterwood and the single tree selection systems. These systems are meant to retain timber value for future harvests and also to provide sufficient space for forest regeneration.

Where non-timber objectives (such as protection of visual corridors) drive management decisions to use dispersed retention these silvicultural systems are often compromised, as they were not designed to accommodate multiple harvests in very old stands with mistletoe, heartrot, windthrow and deep shade.

A cornerstone of forest management is choosing and applying a silvicultural system to a harvest area that allows extraction of current timber value while providing for similar values in the future. This investigation found that the current approach of high-retention harvesting achieved the first objective (extraction of timber value in the present day), but does not promote timber values into the future. It is important to note, however, that the blocks examined were all in compliance with current forest practices legislation.

The extent of high-retention harvesting is, so far, limited. Approximately 1,500 hectares are harvested annually, extracting about 400,000 cubic metres of high value wood, principally cedar. This constitutes approximately five percent of the annual harvest on the coast. However, a significant portion (20 to 60 percent) of the harvest in the three timber supply areas (TSAs) on the north and central coast use high-retention harvesting systems.

There are basically two challenges for sustainability here. First, the trees left behind have insufficient timber value for a future harvest. Most of these trees are mature and over-mature, low-value hemlock with significant decay. Second, these trees shade and occupy growing space, precluding the establishment and growth of a new crop of trees of a more desirable species. Unfortunately, these stands are being classified as "stocked," because provincial policy considers the trees left behind as acceptable free-growing stems. A number of issues have been raised by this investigation:

- On nearly all the blocks reviewed, there has been a species profile shift from high cedar composition to lower value hemlock-dominated stands. Depending upon the remaining value, there may be limited options for subsequent entries.
- The reasons for prescribing a high retention cut were often described as necessary to meet other objectives (like visuals). In some cases these reasons were found to be substantiated, but in others these concerns were not evident in the field.
- Although some site plans projected future growth and harvest levels, none of the site plans examined by the Board projected a reduction in volume production or a species shift as a result of the partial harvest approach, when there clearly would be.
- There was usually a "disconnect" between what site plans prescribed and what was implemented on the ground, with nearly all sites having higher retention than prescribed.
- On the north coast, site plans and silvicultural prescriptions were very similar to one another despite site differences, and often did not describe actual site condition. They also provided insufficient data on the relative vigour of existing and target trees for each site.
- Blocks were often not planted, as under current Ministry of Forests and Range (MFR) stocking standards they do not need to be. Instead there was reliance on release of understory, or natural regeneration, which will almost certainly encourage hemlock and true fir growth, rather than regeneration of higher-value cedar.
- Dwarf mistletoe is not always being managed appropriately, leaving abundant infected trees in residual stands, which will negatively impact strategies for natural regeneration of vulnerable hemlock. In some cases, however, blocks that were initially designed for partial harvest were heli-clearcut due to the presence of mistletoe.
- On the north coast, slash levels in some blocks are high, but planting spots are still available; however, distribution of stock will be irregular.

Board Commentary

This special investigation illustrates that sustainable timber objectives on high-retention cutblocks on the central and northern B.C. coast are largely not being met. There are a number of issues that arise from this investigation:

One of the main issues is transparency. Kimmins[1] (1997) said that, "timber mining is not necessarily an inappropriate management goal; however, its danger for the forestry profession is not inherent in the practice itself, but only when it occurs consciously or unconsciously under the guise of sustained yield. To do so only further diminishes the credibility of foresters in the eyes of the public and the scientific community."

Many of the stands examined in this investigation are being "high-graded" to meet today's economic needs, but it is at the expense of future opportunities. While high retention harvesting appears green – because the majority of trees are left behind – and meets some environmental and social objectives, it does not result in sustained yield forestry or eco-system based management (EBM).

Basically, high retention harvest is, at best, a logging practice with provisions to leave an adequate amount of standing timber to protect other values. While it may be decided that this is an acceptable harvest practice in coastal B.C., professional foresters and government need to engage in public discussion on management objectives for these forests.

Sometimes high retention harvesting is done under EBM, which is meant to balance economic and ecological benefits over the long term. However, the EBM system does not necessarily require high levels of dispersed retention. Relatively "open group" retention systems or "clearcut-with-reserve systems" may be adequate. EBM and high retention harvesting can be complimentary, but only if not high grading. Discussion to ensure the environmental, social and economic objectives of EBM are not compromised is required.

Another issue is professional stewardship. The concept of "sustainability" is recognized as a method to encompass an ecosystem's ability to produce habitats, visual landscapes and cultural values, as well as timber flow, over time. The role of the professional forester is to thoughtfully balance these multiple resource objectives for the land owner and to point out tradeoffs and risks. Stewardship planning for long-term timber values can be a significant challenge for a professional forester, however, because provincial legislation, policies and current economic requirements force attention on short-term gains, often at the expense of long-term planning.

[1] *Kimmins, J.P., **Forest Ecology**, 2nd Edition, Prentice Hall,(1997), p. 596*

A silvicultural system is a planned program of treatments during the whole life of a stand, designed to achieve specific stand structure objectives. In many of the cutblocks reviewed in this investigation, the "silvicultural system" was simply a rationale for harvesting a portion of the species profile that is presently desirable from an economic standpoint.

Professional foresters write silviculture prescriptions for harvesting in these marginally economic stands; however some of the prescriptions have little hope of ensuring future timber harvest within a reasonable period of time. Further, some professionals use boilerplate prescriptions that, in some cases, don't reflect actual site conditions.

The Board found that there were many instances where prescriptions made by professional foresters were not implemented on the ground. In many cases, the level of retention was higher than prescribed and measures described for treating mistletoe were not followed. Even if the prescription was reasonable and had good chance at success, the lack of implementation jeopardized potential for re-establishing economically viable stands.

Since the Board began this investigation, the Coast Region Implementation Team (CRIT), a Ministry of Forests and Range (MFR) / industry working group, has been tackling the issue of high retention harvesting. As part of its efforts to address the issue, a workshop was held in Tofino in October 2007 to address options and direction for high retention harvesting. The approach the CRIT is taking to resolve these issues is consistent with the Board's conclusions and recommendations.

Recommendations

In accordance with section 131(2) of the *Forest and Range Practices Act*, the Board is making the following recommendations:

1. The current regulations and policies do not provide strategic direction to help determine when silvicultural systems and/or harvest approaches with high amounts of retention should be used. The Ministry of Forests and Range should provide strategic direction to guide licensees on appropriate approaches for high amounts of retention, based on clear strategic objectives for the full range of values over time, including timber species/values.

2. In addition, the Association of BC Forest Professionals (ABCFP) should provide guidance to members to ensure they are using appropriate professional diligence in the design of high retention silvicultural prescriptions on the coast.

3. The Ministry of Forests and Range should require clear, achievable and measurable up-front targets for post-harvest retention levels. Stocking standards should require the use of residual basal area ranges with compliance limits at both the lower and upper end. Some characterization of vigour and economic viability should be used to allow trees to contribute to stocking. Ultimately, retention stocking standards must be designed so they can be audited for compliance, and monitored for effectiveness.

4. The Ministry of Forests and Range should develop policy about 'opportunity cuts' with no expectations of future yield (and therefore no silvicultural system) which should be considered, for example, in areas constrained from harvest due to other objectives, such as slope stability concerns.

The Board requests that the Ministry of Forests and Range advise the Board of progress in implementing recommendations 1, 3, and 4 by July 31, 2008, and that the ABCFP advise the Board of progress in implementing recommendation 2 by July 31, 2008.

Introduction

BACKGROUND

Variable retention silviculture using partial cutting has become increasingly widespread in British Columbia forestry in recent years. There are biological, social, and administrative reasons for the interest in retention systems. One benefit is that structural elements of the existing stand are retained for the long term throughout a harvested area to achieve specific silvicultural, ecological, habitat, biodiversity and economic objectives. Other documented benefits include reducing the impacts to focal bird species such as marbled murrelet and goshawk, reducing slope instability, reducing the incidence of windthrow, reducing hydrological change, conserving fish habitat, enhancing protection of riparian areas, maintaining visual quality and protecting cultural features.

Retention is a silvicultural system that retains trees or groups of trees during a harvest as a way to maintain structural diversity over the whole area of the cutblock for at least one rotation. The retention system requires a reasonable distribution of retained timber across the whole cutblock, generally interspersed with open spaces for regeneration. A range of stand volume can be left on the block, depending on required objectives that have been put forward in the forest development plan. For the purpose of this investigation, a high-retention system is defined as one that leaves a minimum of 30 cubic metres per hectare of residual basal area (RBA) dispersed throughout the harvest area (see Figure 1).

With low volume removals, the character and structure of a pre-harvest stand is kept relatively intact, which can result in stands that continue to fully occupy their growing spaces immediately after harvesting. However, future harvesting for economic purposes may still be feasible if sufficient value (species and volume) remains. Conversely, with slightly higher volume removals, most of the stand value may be extracted but this still may not allow enough light for regeneration, making future harvest uneconomically viable.

Economic pressures such as remote locations and high harvesting costs can induce what is commonly known as, "high-grading." This is particularly the case with helicopter yarding systems, where single, commercially valuable trees can be extracted one by one.

Smith[2] (1986) defined high-grading as, "harvesting the best and leaving the poor," and described it as follows:

> *"This kind of cutting can result from a single-minded concern about avoiding the high cost of small trees. Even more short-sighted is the policy of regarding the stand merely as a magic warehouse into which one ventures sporadically attempting to find trees that will meet the specifications for current orders, ultimately leaving stands of poor trees that cannot be harvested economically by the most ingenious logging or the most astute salesmanship."*

[2] *Smith, D.M.,* ***The Practice of Silviculture****, 8th edition, John Wiley and Sons, 1986.*

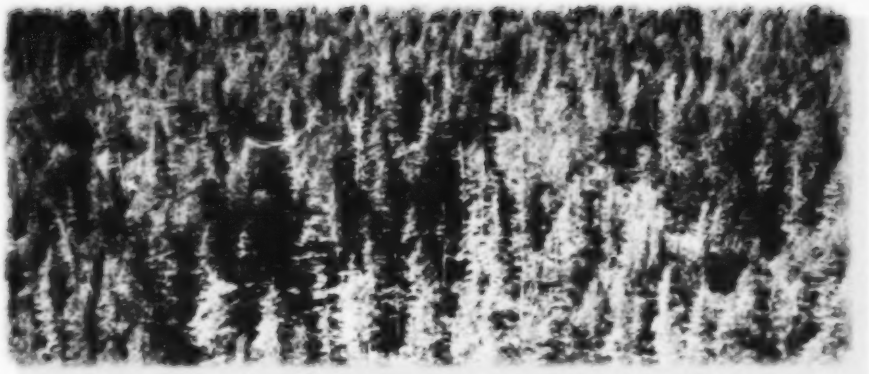

Figure 1: *High retention harvesting area – it is often difficult to see harvesting, even from above.*

Figure 2: *Typical group retention system with open areas for regeneration – this is NOT considered high retention.*

Figure 3: *Small gap created in high-retention block; limited space for new regeneration and limited future harvest options.*

OBJECTIVE

The objective of this special investigation was to examine the sustainability of timber supply in areas with high retention harvesting on the Queen Charlotte Islands and the central and northern B.C. coast by assessing post-harvest stand structure and condition in recent cutblocks.

The investigation did not explicitly examine the maintenance of other forest values, such as soils, water quality or biodiversity, though it did consider these values for context, recognizing that they are often the reason for the partial cut prescription in the first place. Non-sustainable harvesting may be acceptable if the post-harvest forest condition represents the best that can be done while meeting the non-timber objectives; however, this "trade-off" was not examined in the investigation as the sole focus was on post-harvest timber values.

This report is not about compliance with either the *Forest and Range Practices Act* (FRPA) or the *Forest Practices Code of British Columbia Act* (FPC). It is about the effectiveness in achieving government's objectives. The purpose of this type of Forest Practices Board investigation is to assess the effectiveness of current forest practices and recommend improvement to policies or legislation where warranted.

The investigation was carried out in the north coast, central coast and Queen Charlotte Island forest districts. All sites are within the coastal western hemlock biogeoclimatic zone, and tree species are dominated by western red cedar, yellow cedar, western hemlock, amabalis fir and Sitka spruce. Four forest licensees conduct operations in the area investigated. Only cutblocks harvested after 2002 were assessed, all of which were yarded by helicopters.

APPROACH

According to Beese and Zielke[3] (1999), who reviewed the existing literature on the topic, partial cutting using a well-designed silvicultural system is sustainable when: 1) desirable timber species are regenerated; 2) site productivity and quality is maintained over time; 3) a healthy gene pool of the desirable species is maintained; and, 4) a decline in stand health is avoided.

In a partial cut situation where lesser amounts of high-value trees are harvested, site growing space is largely captured by the remaining canopy trees. Seedlings and saplings cannot readily grow into the canopy, so value production must come mainly from residual canopy trees. Ultimately, removing the high value component thus reduces both current value and value production potential.

In a partial cut situation where heavier amounts of multi-value trees are harvested, seedlings and saplings are required to augment the retained trees to fully capture growing space. However, if too many of the retained trees are of poor quality, they greatly reduce the growth of the seedling/sapling layer while not contributing value growth themselves.

[3] *W.J. Beese and Zielke, K.,* ***SPs for VR: Guidelines for Designing Variable Retention—Layout and Silviculture Prescriptions****, 3rd Edition, Weyerhaeuser, BC Coastal Timberlands, August 1999, March 2004, Chapter 5: Partial-Cutting to Avoid High-grading.*

The impact of partial cutting on the FRPA goal "to maintain or enhance an economically valuable supply of commercial timber," can therefore be assessed through its impact on unit-area-volume and value. Both the current post-harvest volume and the potential of the partial cut area to "re-grow" need to be considered. The timber goal will be met when the post-harvest growing space is fully captured and value production potential is maintained or enhanced.

Conceptually, a sustainable silviculture prescription should allow for sufficient open space for new regeneration, and should provide sufficient volume and value of retained timber to allow for a subsequent entry. The Board used four indicators to reflect this model:

1. Basal area of commercially valuable overstory trees.
2. Percent of value removed to percent of basal area removed.
3. Basal area of trees of poor timber quality.
4. Degree of site occupancy by quality seedlings and saplings.

As well, investigators anticipated three high retention scenarios:

Type 1

Stocked by overstory, value removal does not exceed volume removal (harvesting the profile).

In the "harvesting the profile" scenario, the proportion of value extracted does not exceed the proportion of volume extracted, and cutblocks have a very light – usually single-tree – harvest, with a high retention of economically valuable, healthy trees. The resultant stands are similar in structure and species profile to the pre-harvest stands, thus, if there was a high value component in the original overstory, as long as the retained trees remain healthy, it is maintained until the next harvest entry. Cutblocks managed in this way will have sufficient volume of economically valuable stems remaining for subsequent harvest, and this future harvest is not dependant on regeneration or understory release. In this high retention scenario the growing space is fully occupied by the remaining canopy so no new regeneration is required. This scenario meets the FRPA timber objective in the short term.

Type 2

Stocked by overstory, value removal greatly exceeds volume removal (high-grading); inadequate sites for regeneration.

In the "high-grading" scenario, the proportion of value removed by harvest greatly exceeds the proportion of volume removed, and growing space is fully occupied by the remaining canopy trees. Once the high value component of the overstory is removed, the remaining overstory suppresses seedling and sapling growth, so the remaining canopy trees become the sole source of future value production. However, since the canopy is dominated by the retained lower value trees, the stand is unlikely to grow valuable timber in any foreseeable future. In the high-grading scenario, the immediate supply of valuable timber is not maintained, nor is it maintained or enhanced for the future. This type of scenario does not meet the FRPA objectives for timber.

Type 3

Stocked by overstory, value removal exceeds volume removal; substantial forest health problems due to dwarf mistletoe.

A forest health concern is the infection of new hemlock regeneration by mistletoe that can potentially spread from infected overstory hemlock. Western hemlock dwarf mistletoe (Arceuthobium tsugense) is a parasitic plant that reduces volume production and can reduce the value of hemlock sawlogs. If mistletoe infection occurs, as the young trees grow, they continue to be infected by the overstory mistletoe source, reducing growth and affecting form.

As with the high-grading scenario, in the "health problems" scenario, the proportion of value removed also exceeds the proportion of volume removed. Again, growing space is fully occupied by the remaining canopy trees. Seedling and sapling growth is greatly suppressed and leaves the remaining canopy trees as the sole source of value production. However, since the canopy is dominated by the lower value western hemlock component, and this component is infected with dwarf mistletoe, the immediate supply of valuable timber is not maintained or enhanced for the future. This scenario also does not meet the FRPA objectives for timber.

METHOD

The investigators took samples of high retention cutblocks from the provincial silvicultural database, RESULTS.

Unfortunately, as there is no specific field within RESULTS that identifies the amount of retention left on site, investigators had to use surrogate values, in this case cutblocks that:

- used multi-layer stocking standards; and
- had more than 50 percent of harvest volume consisting of western red cedar or Sitka spruce.

One hundred cutblocks met these criteria. Sample cutblocks were then further stratified by licensee, and, of those, 54 were chosen for field inspection. The investigators then reviewed silvicultural prescriptions, site plans and ancillary documents for all 54 cutblocks.

In the field, investigators established five to ten plots, 100 metres apart, in each cutblock opening. The plots were located so that retained structure and regeneration could be measured – they were not a 'silviculture survey.'

A basal area factor prism identified overstory and the harvested stems within each plot. Data was sorted by species, diameter and vigour category. Stumps were tallied by size and species. Additionally, a 3.99 metre radius plot was tallied for the categories of "well-spaced" and "total stems per hectare."

Table 1 - Criteria used to assess vigour of leave trees

GOOD/ ECON[4]	**HIGH VIGOR** **– HIGH PROBABILITY OF PERSISTING THROUGH ROTATION** • **No heartrot suspected.** • **AND 40%+ live crown (H, Ba, C, Y) / 30%+ (Fd, P) / 25%+ (broadleaf).** • **AND foliage has normal, healthy color.** • **AND tree is highly windfirm – there is a high chance that the tree will remain standing until the end of the rotation.**
FAIR / ECON	**MODERATE VIGOR** **– MODERATE PROBABILITY OF PERSISTING THROUGH ROTATION** • **Heartrot unlikely or insignificant.** • **AND 20%+ live crown (all conifers) / variable - (broadleaf).** • **AND foliage has normal, healthy color.** • **AND tree is moderate to highly windfirm – there is a reasonable chance that the tree will remain standing until the end of the rotation.**
POOR / UNECON	**POOR VIGOR** **– LOW PROBABILITY OF PERSISTING THROUGH ROTATION** • **Heartrot is significant.** • **OR < 20%+ live crown (all conifers) / variable - (broadleaf).** • **OR foliage is patchy and sparse.** • **OR foliage has an abnormal, unhealthy color.** • **OR tree is NOT windfirm – there is a low chance that the tree will remain standing until the end of the rotation.**

[4] *Economic strictly from a wood quality standpoint – not species and grade (size).*

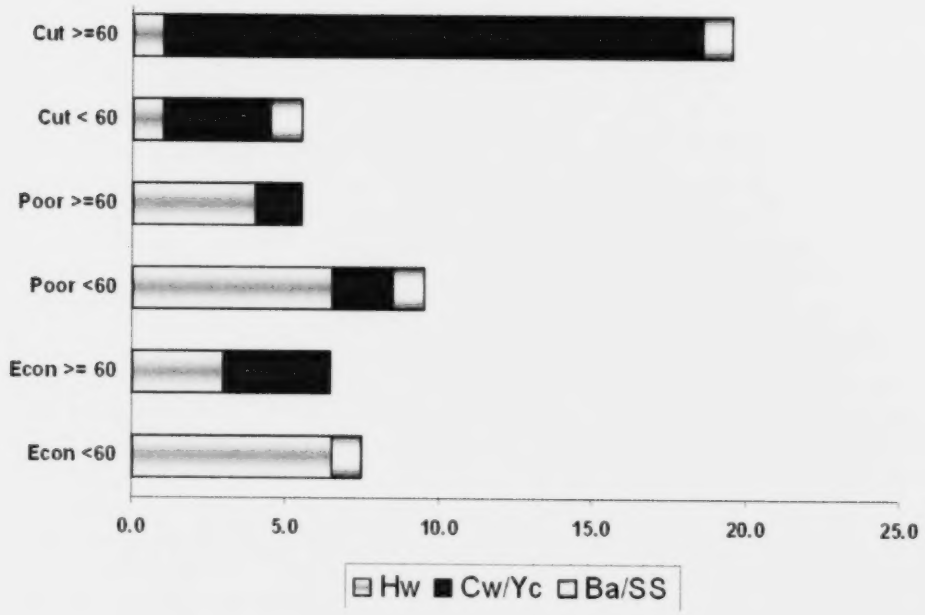

Figure 4: *An example to illustrate the method – for each block, stems classified as having poor vigour, or those identified as having good or fair vigour, were graphed as Econ or Economic. Species are identified by different colours and subdivided into size categories – less than 60 centimetres diameter (DBH) and equal to, or greater than, 60 centimetres DBH.*

For example, the above graph shows high levels of cut cedar (Cw) that is greater or equal to 60 centimetres DBH. Most of the remaining volume is hemlock (Hw).

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Results

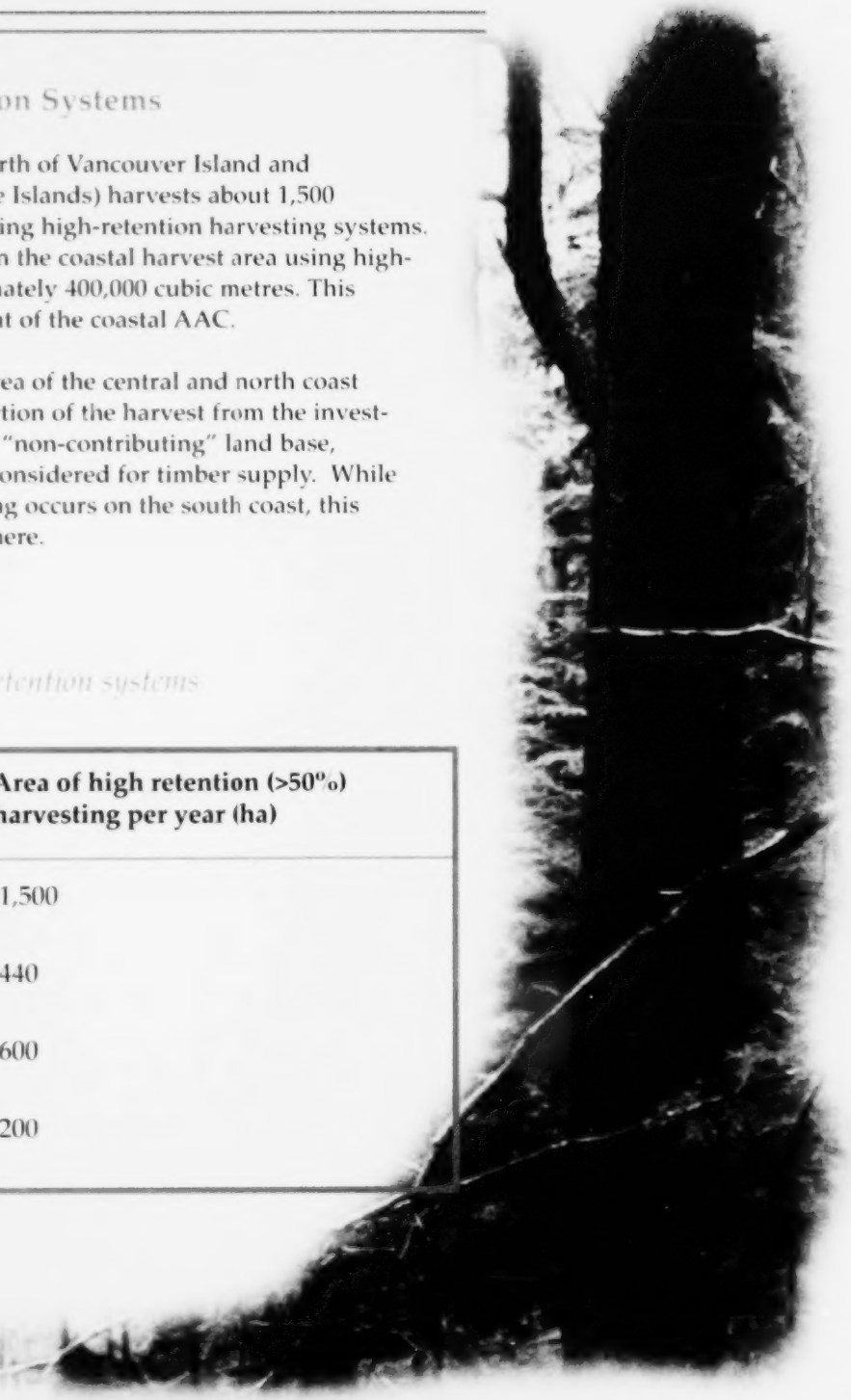
Extent of High Retention Systems

The northern coast region (north of Vancouver Island and including the Queen Charlotte Islands) harvests about 1,500 hectares of timber per year using high-retention harvesting systems. The total annual volume cut in the coastal harvest area using high-retention systems is approximately 400,000 cubic metres. This represents about seven percent of the coastal AAC.

Only 10 percent of the land area of the central and north coast contributes to the AAC. A portion of the harvest from the investigation area is taken from the "non-contributing" land base, meaning areas not normally considered for timber supply. While some high-retention harvesting occurs on the south coast, this system is used sporadically there.

Table 2 - Area using high retention systems

Area	Area of high retention (>50%) harvesting per year (ha)
Coast Region	1,500
North Coast TSA	440
Central Coast TSA	600
QCI TSA	200



Background Conditions

Systems with high retention levels are often well suited to meet non-timber management objectives. In some cases, prescriptions to address multiple objectives are needed. Success in achieving these non-timber objectives was not explicitly assessed in this investigation; however a summary of the concerns provides some context:

Non-timber management objectives for:

i. **Visual landscape management, ranging from a visual quality objective (VQO) of "partial retention" to "retention."**

Thirty of the 50 blocks (60 percent) had visual objectives specified in their management plans. High retention harvesting allowed all visual objectives to be met.

ii. **Cultural /archaeological values, such as retaining the presence of culturally modified trees.**

Ten of the blocks (20 percent) had goals to preserve culturally modified trees specified in their management plans. High retention allowed for maintaining no-harvest areas around all of them.

iii. **Exposed crown area (ECA) limitations over the watershed.**

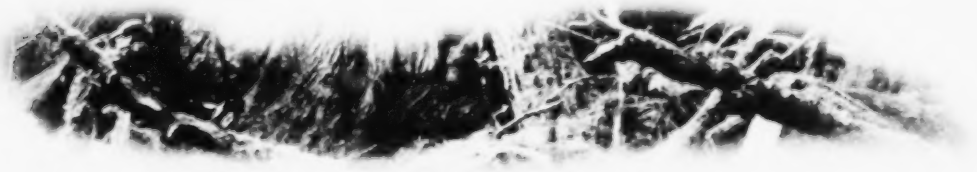
Three watersheds had rate-of–cut concerns specified in their management plans. High retention harvesting avoided increasing open areas.

iv. **Marbled murrelet strategy.**

Two cutblocks included potential marbled murrelet habitat management in their plans. High retention harvesting allowed for the leaving of potential nesting trees.

v. **Site sensitivities, such as unstable slopes with a moderate to high risk of failure if clearcut.**

Potentially unstable slopes were identified on eight of the blocks (16 percent), and high retention harvesting minimized risk. On four of these, there were no apparent slope instability problems.



Types of Retention

Type 1
Stocked by overstory, value removal does not exceed volume removal, no regeneration objective.

Type 1 retention ("harvesting the profile") had been used in 18 blocks, or 33 percent of the sample.

1. The amount harvested varied from a low of four square metres to a maximum of 33 square metres of basal area per hectare.
2. The resultant stand retained between 53 and 87 percent of the original basal area.
3. An average of 25 square metres per hectare of basal area with fair or good vigour was retained.

Table 3 - Levels of harvest and retention in Type 1 blocks

Block number	Amount Harvested (m^2/ha)	Percent of Harvest	Percent of retention	RBA	Percent F&G	RBA F&G	NAR	Total NAR	Blocks/ SUs	Percent by Category
SB205	33	40	60	49	53%	26	7			
H77b	4	13	87	26	38%	10	21.9			
F3B	31	44	56	39	56%	22	40.1			
DIV107	24	33	67	48	54%	26	41			
DIV105	16	25	75	48	44%	21	8.6			
DIV104	15	26	74	42	57%	24	18.8			
MC13A	15	22	78	53	45%	24	17.6			
MC13B	12	19	81	51	63%	32	25.7			
MC20	15	21	79	54	44%	24	43.3			
RIL329	11	17	53	50	40%	20	22.4			
NAD515	14	22	78	51	55%	28	17.1			
MC14B	11	14	86	67	45%	30	27.5			
GRE309	18	24	76	56	48%	27	17.6			
DIV108	16	23	77	55	47%	26	18.1			
LIG065B	18	21	79	67	36%	24	11.3			
DAV203	24	41	59	35	51%	18	39.4			
RIL336	12	20	80	46	46%	21	24.5			
GRE301	13	13	87	81	59%	48	36.3			
	16.8	24.3	74.0	51	49%	25.1	24.3	437.8	18	46%

Table 3: *Provides block information on the amount harvested; the percentage of the original stand remaining; the percentage of basal area (BA) that was retained; measured residual basal area (RBA); percentage of the RBA that was typified as Fair or Good (Econ on the graphs); actual RBA of Fair and Good stems; and, the net area to be reforested (NAR) of the block. For each category an average was provided in the bottom row.*

Prescribed retention levels are block-specific, but the minimum retention level was 40 percent, and could range up to 85 percent. One licensee has a policy to retain up to 33 percent of old-growth trees that have diameters greater than 125 centimetres. For the most part, there are future options for these stands, and a second pass harvest could take place at any time. However, each stand is now too stocked to allow for regeneration. With only about 50 percent of fair to high quality stems remaining to add incremental value, there will be growth loss over time. In all cases, western hemlock is considered a preferred species, but the species actually harvested on most sites was mainly western red cedar and/or Sitka spruce.

On the Queen Charlotte Islands, the licensee used stand/stock tables; target basal area and maximum diameter to determine cutting rules, so as to ensure that the next cutting phase will achieve their objectives. It may take several cuts to convert a multi-aged forest into a 'selection' forest, and there are concerns with this approach because it is uncertain when the next planned cut will actually occur. The future harvest value of residual stands is also uncertain because insufficient light to allow for vigorous regeneration will impede future harvest. It may also be prohibitively expensive to use a helicopter in periodic 'improvement cuts.'

Example one of a Type 1 block (Figure 6) showed a very light harvest (14 percent) of a low value stand (86 percent retention). The species profile was retained by harvesting all three species. There was adequate stocking of overstory sized spruce (greater than 60 centimetres) to warrant a second cut. This block will continue to develop as it was prior to harvest, although with fewer large trees. However, there is limited space for new regeneration, and the trees currently on site will continue to grow or rot depending upon their relative health. To promote timely ingress, a system that creates gaps and is regenerated with cedar and spruce (group selection system) would be preferable.

Figure 5: *Example of light harvest level with harvest options.*

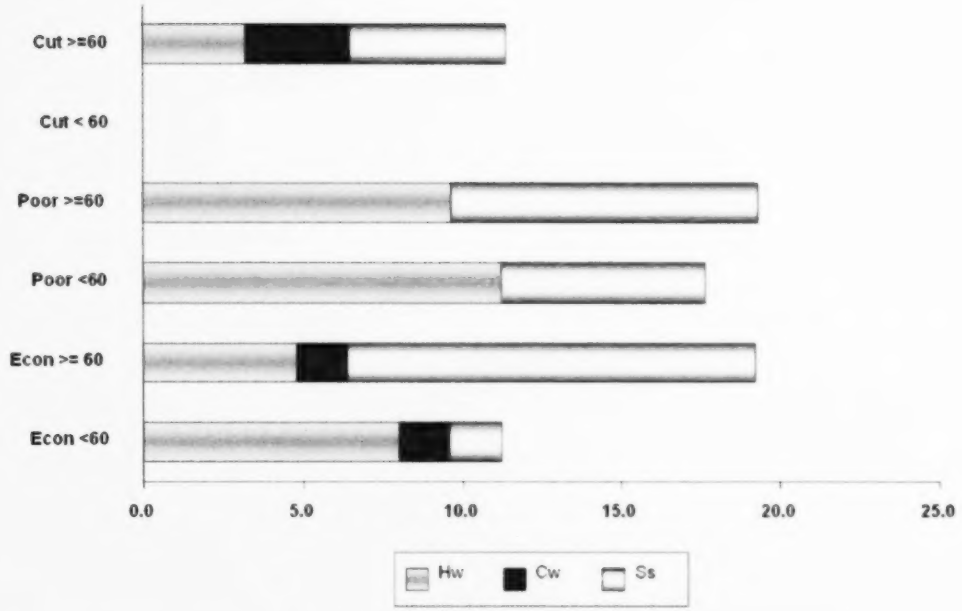


Figure 6: *Cutblock Example 1, harvest and retention by species, diameter and condition.*

Figure 7: *Example 1, light removal, value remains.*

Example two of a Type 1 "harvesting the profile" example had a light dispersed harvest of 14 percent of the stand. There was a potential for increasing volume in this stand, due to high numbers of healthy trees in both the economic size classes and due to the amount of healthy vigorous mid-sized stems, there was also an immediate opportunity for a two-pass system.

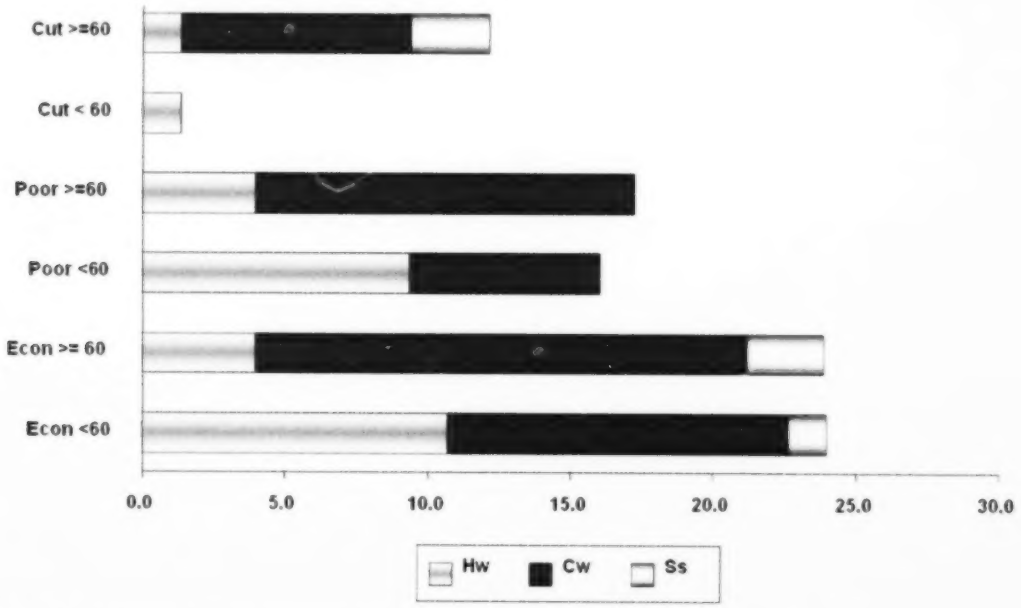


Figure 8: *Example 2, light dispersed harvest.*

Figure 9: *Example 1, light removal, value remains.*

A third example of Type 1 (figures 10 and 11) was a block where 22 percent of the stand basal area was harvested, leaving 78 percent. Again, the harvest had focussed almost solely on large diameter cedar (greater than 60 centimetres).

There was a sufficient level of economic grade large and small diameter cedar to allow another entry. The vigour and space available for growth of understory remained limited, so most of the future growth will be on larger trees. Recruitment from smaller sizes will be limited because their growth rates are relatively slow.

Figure 10: *Example 3, good quality cedar removed.*

Figure 11: *Block summary graph of a block with only large diameter cedar removed, but also a good crop of large diameter cedar remaining on site. With approximately 50 metres squared per hectare residual basal area (RBA), natural hemlock will establish, but grow slowly without removal of more of the overstory.*

Type 2
Stocked by overstory, value removal greatly exceeds volume removal; inadequate sites for regeneration.

A total of 21 cutblocks (40 percent of the survey sample) was Type 2, "high-grading."

These blocks had few future harvest options because there was too little retention of economically valuable trees because most of the higher value stems had been removed. The quality of the retained trees for a second pass was marginal at best because the more valuable western red cedar or Sitka spruce had already been harvested, leaving poor quality volume dominating much of the block. This condition will be sustained for a long time, as there is still too little light and growing space for understory establishment and growth. Poor future harvest prospects are a result of low volumes of "good" and "fair" quality (economic) stems retained, as well as the lower value species composition of the retained trees.

In most cases, regeneration will be limited without further overstory removal. Approximately 30 percent of the plots examined by the Board had retained trees that were fully occupying the site. An additional 54 percent had moderate stocking, therefore, part of the opening would have space for some regeneration, but with reduced growing potential due to overstory shading. While these retention levels offer some opportunity for understory establishment and growth, they are limited, with an anticipated 50 to 80 percent reduction in understory volume growth.

Cutblocks with limited options had:

- a residual basal area between 21 and 56 square metres per hectare, averaging 36 square metres per hectare (Table 4).
- only 38 percent of the residual basal area potentially economic, some 13 square metres per hectare.

Many of the high-grading type cutblocks were on the north coast, an area with highly variable tree productivity and a dominant mature hemlock forest. The licensee pointed out that to successfully implement an alternative silvicultural system with such high costs in an area with a timber profile such as that of the north coast, it is imperative that attention is focussed on both economic value of the harvest and ecological value of the forest retained.

The licensee added that, regardless of the silvicultural system, the economic reality of the north coast is that a large portion of hemlock will remain on site, either as standing trees or as harvested debris. In these systems, the licensee considered it to be common practice for harvest areas to be concentrated around the highest value species and the highest volume areas.

Upon completion of the stocking survey done after harvest in order to assess post-harvest stocking and species, the licensee has committed to maximizing the proportion of cedar component in planted stock, within the limits established under approved stocking standards.

Table 4: Cutblocks of Type 2 "high-grading." No harvest options remaining.

Block number	Amount harvested m/ha²	Percent harvested	Percent retention	RBA	Percent F&G	RBA F&G	NAR	Total NAR	Blocks/ SUs	Percent by Category
NAD48C&D	11	21	79	42	55%	23	13			
MC14A	19	25	75	56	34%	19	25 7			
DAV202	30	36	64	53	25%	13	25 6			
C11	20	29	71	50	18%	9	14 1			
KH12A	25	38	62	41	34%	14	22 8			
Block 6	59	74	26	21	62%	13	33 2			
CP81	55	65	35	29	45%	13	18 7			
HI350	24	47	53	27	41%	11	31			
HI340	34	57	43	26	12%	3	22			
SB201A	32	54	46	27	63%	17	7			
H86closed	27	41	59	40	43%	18	18 6			
BK1A	19	26	74	52	35%	18	43 9			
SH1E	22	32	68	47	45%	21	39 2			
FH2A	25	46	54	29	48%	14	47 8			
P2L	18	39	61	27	22%	6	33 3			
BK1D	26	40	60	39	49%	19	122 8			
SH2H	24	48	52	26	31%	8	14 7			
FH3C	13	27	73	33	48%	16	16 6			
FH2B	23	50	50	23	17%	4	77 5			
BK2A	45	56	44	29	48%	14	36 6			
BK1C	30	50	50	30	27%	8	10 7			
	27 7	42 9	57 1	35 6	38%	13 4	32 1	674 6	21	54%

Provides block information on the amount harvested; the percentage of the original stand remaining; the percentage of basal area (BA) that was retained; measured residual basal area (RBA); percentage of the RBA that was typified as Fair or Good (Econ on the graphs); actual RBA of Fair and Good stems; and, the net area to be reforested (NAR) of the block. For each category an average was provided in the bottom row.

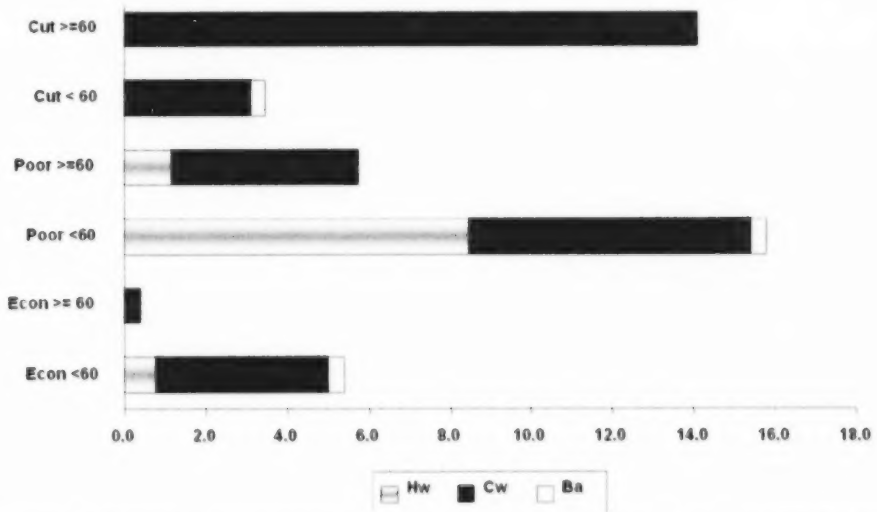


Figure 12: *Example 4, entire harvest was in large diameter cedar; residual forest in poor quality cedar and hemlock.*

Example four (figures 12 and 13) had 39 percent basal area removal. Virtually the entire harvest consisted of large diameter cedar, leaving poor quality hemlock and poor quality cedar overstory, which was also rife with dwarf mistletoe.

This site will have static to declining volume for future harvest, due to the low amount, poor vigour and poor species composition of the remaining trees. Most of the area currently has from 20 to 40 square metres per hectare RBA, which limits regeneration growth substantially. As well, this block is unlikely to develop economic harvest options that would open up the understory for added light and potential growth. Without that, regeneration growth will be limited indefinitely by low light levels, and areas that are more open will require planting in order for desired species to propagate.

Figure 13: *Example 4, Selected larger cedar removed.*

Type 3:
Stocked by overstory, value removal exceeds volume removal; substantial forest health problems.

This "health problems" type characterized 15 cutblocks, or 27 percent of the sample.

These cutblocks have similar characteristics to the "high-grading cutblocks," with the additional complication of high levels of hemlock dwarf mistletoe in the stand. In high retention blocks, mistletoe reduces tree vigour and merchantability. Infection of the understory is not, however, a major concern in high retention blocks because mistletoe is a natural part of these stands and has been identified as an agent in gap creation that provides opportunities for non-infected stems such as western red cedar[5]. However, understory infection is a concern in moderate retention cutblocks. Twenty percent of these cutblocks had moderate to high levels of residual mistletoe[6], and an estimated 60 percent of these areas will experience some growth and value reduction because of the presence of mistletoe.

In many cutblocks, there has been a shift in the species profile of the stand to that of being dominated by hemlock. An example is a hemlock-spruce block on the Queen Charlotte Islands (figure 14). About 30 percent of the stand was harvested (70 percent retention). All of the Sitka spruce and most of the economic quality hemlock were cut from the stand, leaving a pure hemlock stand of poor quality and declining volume. Most of the retained hemlock has experienced damage over time from wind, so large basal scars, forks, and other decay indicators are evident. Overstory mistletoe is common. This block was only partially stocked, with predominantly low vigour overstory trees. There is very little future potential harvest from this site.

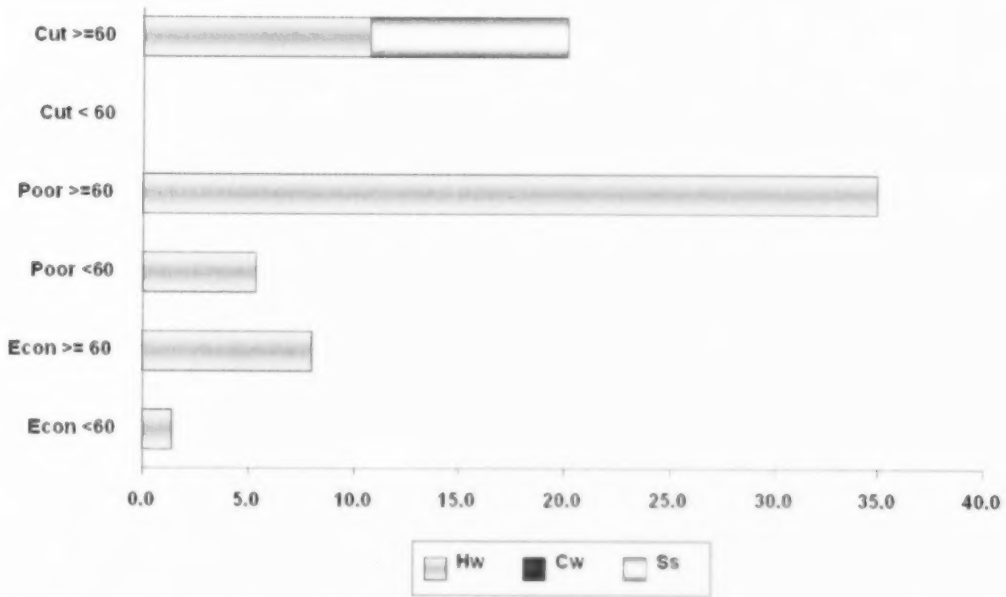


Figure 14: *All spruce and economic hemlock has been extracted, leaving a poor quality hemlock stand.*

[5] *Kimmins as cited by Muir,* ***Simulating Western Hemlock Dwarf Mistletoe Impacts in Coastal British Columbia*** *(undated) http://www.for.gov.bc.ca/hfp/publications/00024/mistletoe.pdf*

[6] *The Hawksworth Typification was used to rate mistletoe abundance.*

Figure 16 is a block with the cedar removed, now consisting of a hemlock overstory with significant mistletoe and slow growing hemlock understory, creating limited regeneration opportunities at this time. The silviculture plan put forward by the licensee proposed to maintain the species composition of the original stand, however, without planting, regenerative success is still unlikely, as western hemlock will continue to dominate.

Additional harvest options for this stand are limited due to the vigour and proportion of the hemlock in the remaining overstory which will compromise understory growth. If the retention were clumped into groups, or more emphasis was placed on creating gaps when harvesting, there would be more open area for regeneration containing the desired structure for diversity and timber production.

Figure 15: *A Type 3 "health concern" block.*

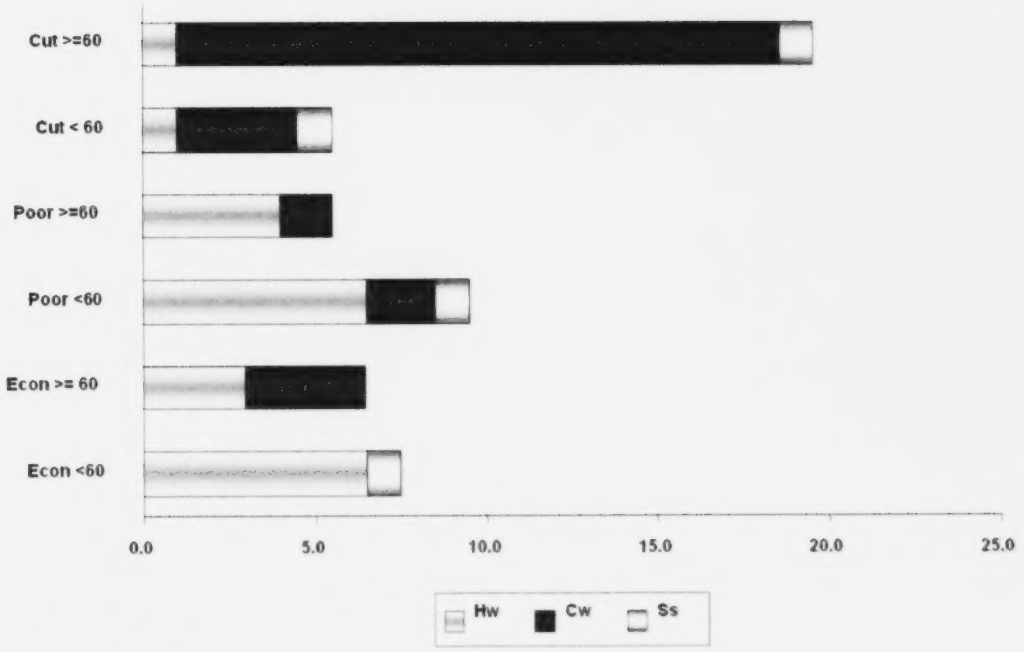
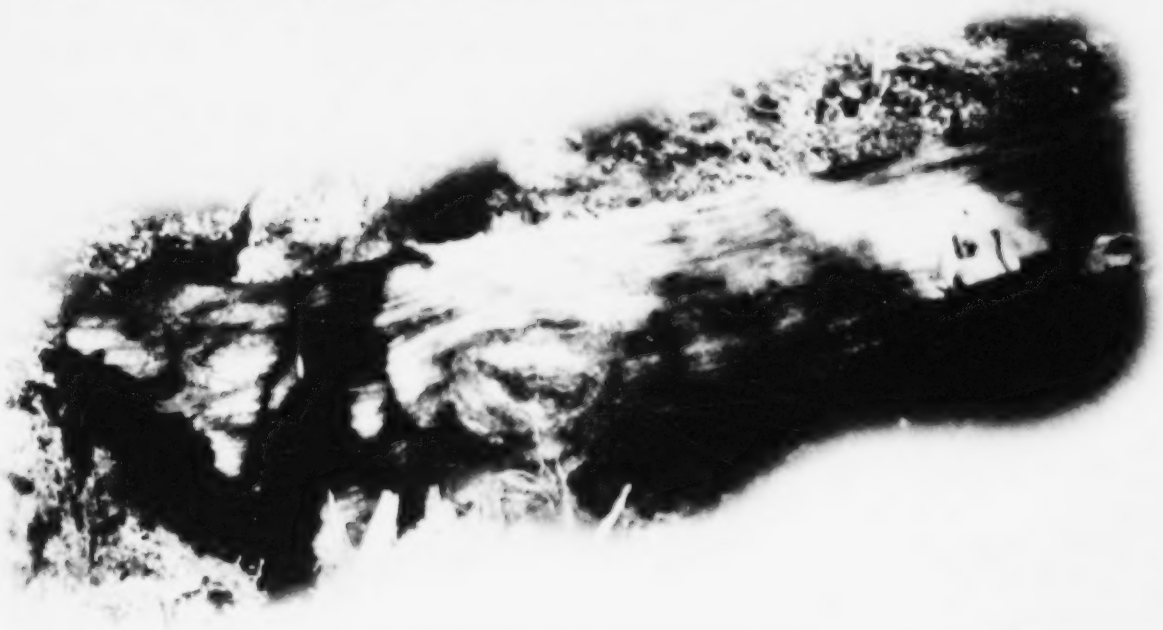


Figure 16: *Block summary graph for a "health concern" block showing almost all large diameter cedar removed and no other species. With approximately 30 square metres per hectare residual basal area (RBA), natural hemlock will establish but grow slowly without added overstory removal.*



Issues

Compliance Versus Effectiveness

This report illustrates the difference between compliance with legislation and effectiveness in managing a resource value. The Board recently audited compliance of one of the licensees whose blocks were examined in this report. The Board found that the licensee was, "in compliance with legislative requirements for planning, harvesting, road management, silviculture and fire protection." The compliance focus did not show, however, that the current stocking standards for high retention harvesting allowed residual, overmature, poor quality trees (mainly hemlock) to be counted as an acceptable, free-growing stock. It is clear that the future stand will have low economic value; while the blocks comply with forest practices laws they have not been effectively managed for future timber values.

Implementing Prescribed Retention Levels

The retention levels specified in site plans were not achieved in many cases, with the amount of retention observed in the field being consistently higher than that prescribed. For example, the average retention on the north and central coast was 58 percent, close to double the specified maximum target value of 30 percent, but the excess retention was mainly of lower value, lower vigour trees. In this case, the higher retention level did not create conditions suitable for regeneration growth, whereas the prescribed values would have resulted in stands with more open areas, allowing considerable space for new regeneration. This discrepancy will affect projected volume production.

Tables 5: Target basal area compared with measure retained basal area.

Block number	Target % of Orig BA	Achievement % of Orig BA
SB205	10-30%	60%
H77b	40% min	87%
HI350	10-30%	53%
HI340	10-30%	43%
SB201A	10-30%	46%
H86closed	30% min	59%
KH12A	30%	62%
Block 6	15-25%	26%
CP81	15-25%	35%

Forecasting Volume Reductions

Forecasting volume reduction from stands with significant retained overstory is an issue that needs to be addressed. For example, a stand with 20 square metres per hectare of dispersed retention, half cedar and half hemlock, will reduce merchantable volume at age 100 by approximately one-half (according to growth and yield modelling). None of the site plans projected a reduction in volume as a result of the partial cut harvesting approach.

Potential for Species Shift

For most of the blocks reviewed, there is a potential for species shift from high cedar component to lower value hemlock-dominated stands. Undisturbed forest floor, high slash loading and low overhead light favour establishment of hemlock[7]. Hemlock is more suited to natural regeneration beneath a canopy than is either western red cedar or Sitka spruce.

On the Queen Charlotte Islands, there will be a species shift away from cedar regardless of the silvicultural system used. The deer population prevents the regeneration of unprotected cedar throughout the islands. The licensee maintains that, in partial cut blocks, the species shift will be the same, regardless of harvesting system.

Figure 17: *A cedar component has been retained.*

[7] *Klinka, 1998 and Klinka et al 2000,* ***The Distribution and Synopsis of Ecological and Silvicultural Characteristics of Tree Species of British Columbia's Forests*** *(for Reference Section).*

For high retention blocks, the species shift will be immediate if cedar and/or spruce is preferentially harvested, leaving hemlock and/or Amabilis fir. Depending upon the remaining timber value, there may be options for subsequent entries. Where cedar is being preferentially logged, it is often species other than cedar left on site, making subsequent entries unlikely (Figure 18).

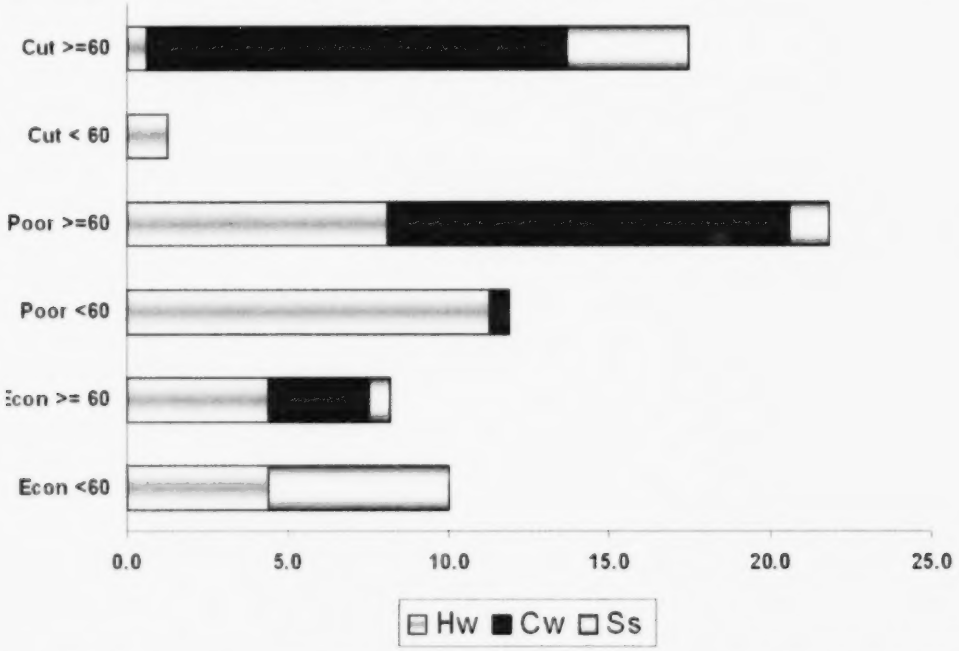


Figure 18: *Block summary graph showing predominantly cedar removed with a mix of hemlock, cedar and Sitka spruce. With approximately 40 square metres per hectare residual basal area (RBA), natural hemlock will establish, but grow slowly without added overstory removal.*

There is even less likelihood of a second harvest for blocks with 20 to 40 square metres per hectare RBA, as there is less timber available for a subsequent entry, and therefore, a higher likelihood of a species shift to hemlock in the understory of such stands. Hemlock grows much more slowly in such dense old stands than when grown in the open, so there will be both a value and volume impact over time.

Impacts on the Growth of Understory Regeneration

Understory trees require light, moisture and nutrients to grow to their potential. When old overstory trees are left on site, they occupy some, or potentially all, of the growing space, while providing little additional new growth to the stand. For most of the high retention blocks (over 40 square metres per hectare RBA), understory growth is not relevant, as these stands are fully stocked with overstory stems; thus, the impact on the understory is not a concern at this time. For all moderate retention blocks (between 20 and 40 square metres per hectare), the overstory will affect timber productivity in the understory, especially if the overstory has low economic value and is itself unlikely to be harvested.

Because high retention systems are not designed to favour regeneration, the professionals should plan for re-entry to open the stand up for future regeneration establishment. If retention was grouped, or if harvesting focussed more on creating gaps to allow for open growing conditions within the harvested area, there would be less impact on long term yield.

Regeneration – Planting and Natural

Site plans indicated a general reliance on natural regeneration. Most indicated there would be a stocking survey conducted a number of years post-harvest and, if stocking is insufficient, planting would occur.

Helicopter logging often leads to high levels of slash, which can be a physical impediment for subsequent treatments. In areas where submerchantable trees are cut and left, rather than extracted, high slash loads will make planting difficult and potentially dangerous, which encourages acceptance of natural hemlock. If western red cedar is planted a number of years post-harvest, competing vegetation and understory hemlock will challenge the survival of the cedar. Even if planted in gaps, cedar may still be affected by local competition, but the trees may ultimately be more valuable than open-grown trees because of smaller limbs and tighter grain. Growth will, however, take longer.

Overall, future planting must be operationally feasible to be a viable option. One concern that affects its viability is the low structural longevity of heli-pads used to access the blocks. Many were made of hemlock or Amabilis fir, both species that rot relatively quickly. Occasionally, heli-pads were buried by wind throw, rendering them inaccessible.

Forest Health – Dwarf Mistletoe (DMH)

In high retention blocks, mistletoe reduces tree vigour and merchantability. Infection of understory is not, however, a major concern, because mistletoe is a natural part of these stands and can create gaps for non-vulnerable species such as western red cedar. In the 23 higher retention blocks, five (22 percent) had moderate to high levels of residual mistletoe[8]. An additional nine blocks (39 percent) had mistletoe that was either patchy or at a relatively low level.

Unlike the high retention blocks, mistletoe is mostly a concern for timber productivity on high to moderate retention blocks. This is especially true if the site is left after harvest to regenerate naturally. All prescriptions examined by the Board identified mistletoe as a potential issue and described methods of dealing with it. In the 18 moderate retention cutblocks, eight (44 percent) had a significant mistletoe component and another three (17 percent) had mistletoe present in the residual stand at lower levels or in isolated pockets. Without some form of intervention, approximately 60 percent of the areas with moderate retention will experience some growth and value reduction from mistletoe. The present stocking standards limit the acceptance of understory stems near an infected hemlock. Thus if the overstory does not stock the site, fill planting may be required in spite of prolific understory hemlock. However, planting may be problematic if delayed until after a problem is noted in a stocking survey.

[7] *Kimmins as cited by Muir, Simulating Western Hemlock Dwarf Mistletoe Impacts in Coastal British Columbia (Undated) (http://www.for.gov.bc.ca/hfp/publications/00024/mistletoe.pdf)*

[8] *The Hawksworth Typification was used to rate mistletoe abundance.*

Figure 19 (2 photos): *Hemlock mistletoe resulting in stem swelling and reduced growth and value.*

Linking Site Plans to Harvesting Outcomes

It was noted during the investigation that there was usually a discrepancy between the site plan and what was implemented on the ground, and it was difficult to determine a direct link between actual practices and reasoning behind the approach. Commonly, site plans used 'boiler plate' objectives, not necessarily relevant to site conditions. In other cases, the site plan described an elaborate hypothetical multi-phase silvicultural system not suited to the actual stand conditions. In many cases, objectives appeared to be clear and reasonable, but were not well tied to the particular conditions or outcomes.

An example from one plan states:

> *"Within the Harvesting Plan - The objective is to provide benefits for a range of other resources such as: wildlife habitat attributes; hydro-riparian retention and stand level, and, biodiversity through retention of old forest attributes through the application of a retention silvicultural system that consists of group and dispersed retention.*
>
> *Future stand structure/composition: Through retention and reforestation management strategies it is anticipated that the future stand will be similar in species composition to the current stand. Forest management activities (reforestation, etc) will generally target species other than Hw (Target species of Cw/Ye and Ba with a minor component of Ss) in an effort to maintain or increase the components of these species."*

In this example, the apparent intent is to manage for western red cedar, yellow cedar and Sitka spruce. However, the present level of overstory (39 square metres per hectare) will not allow for sustained growth of any of these species as understory. The stand will be modified, changing from having a significant level of western red cedar to having only a small amount of economic cedar, high levels of hemlock and uneconomic Sitka spruce and cedar (figure 20). Combined with the moderate to low levels of mistletoe on site, this does not correspond with the species management set out in the silvicultural prescription.

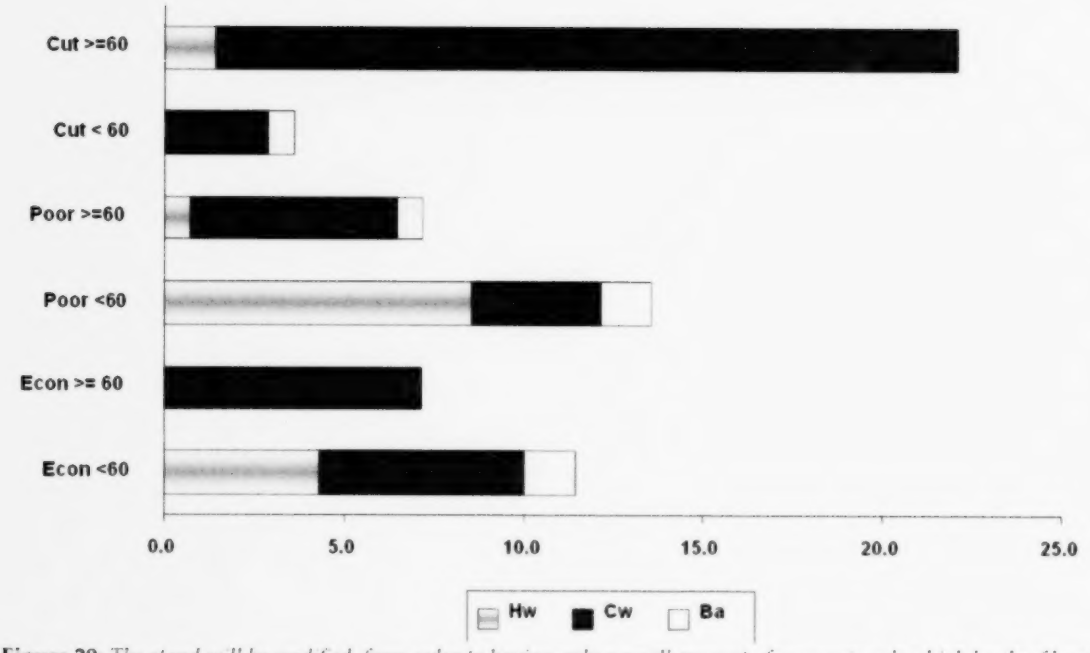


Figure 20: *The stand will be modified, from cedar to having only a small amount of economic cedar, high levels of hemlock and uneconomic spruce.*

Conclusions

The objective of this investigation was to examine the sustainability of the timber value in high retention cutblocks on the B.C. coast. Approximately 1,500 hectares are harvested annually using high retention systems, extracting about 400,000 cubic metres of high value wood, principally cedar. The Board found that high retention systems extract nearly all timber value, but impair development of future crops. On 60 percent of the cutblocks examined, much of the economically valuable cedar and spruce were harvested. There were two challenges for sustainability.

- First, a significant overstory was left that had insufficient value for a future harvest.
- Second, the overstory trees occupy the growing space, which precludes or significantly impacts the regeneration of a desirable species.

The Board concludes that high retention harvesting, while it is visually appealing and it meets many environmental and social objectives, is not sustainable forestry as currently practised.

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